CNTT-E-138

BASIC ELECTRICITY AND ELECTRONICS

STUDENT HANDOUT

NO. 301

SUMMARY PROGRESS CHECK AND JOB PROGRAM FOR MODULE 30-1

U.S. NAVY NAVAL TECHNIC TRAINING

JUNE 1984

FAULT ANALYSIS
(Paper Troubleshooting)

Many of the lessons in the 30 series have fault analysis exercises. These paper troubleshooting problems have been designed to help you think about possible solutions to given troubleshooting symptoms. The problems in these exercises are for actual circuits which you will be troubleshooting on the performance test. You should study the symptoms, and then look at the multiple choice answers. Based on your knowledge of the circuit, which you obtained from the Study Booklet and the job program, you should be able to select one of the choices which will produce the given set of symptoms.

SUMMARY
LESSON 1

Voltage Multipliers

In previous lessons you learned how voltages are increased by the use of a transformer. You also learned that when voltages are increased there is a corresponding decrease in the current output.

This lesson describes another method for increasing voltages. The method is called voltage multiplication and the circuits which accomplish the multiplication are called voltage multipliers. Voltage multipliers are designated as doublers, triplers, or quadruplers depending on the ratio of the output voltage to the input voltage.

Voltage multipliers are used to develop high DC voltage where there is a low current requirement. The most common use of voltage multipliers is to provide DC voltage for the anode of a cathode-ray tube (CRT). Output of voltage multipliers range from one thousand to thirty thousand volts. The actual voltage depends on the equipment application and size of the CRT.

Although the input for a voltage multiplier could be direct from the line, or power source, this is not usually the case for military electronic equipment. Most military equipments use transformer inputs since the transformer isolates the equipment from the line and thereby reduces the shock hazard.

Voltage multipliers are made up of voltage rectifiers which you are already familiar with. The rectifiers may be either full-wave or half-wave, depending on the circuit requirements. You recall that full-wave rectifiers are used when better voltage regulation is needed and that full-wave rectification results in a reduction in the output ripple amplitude and an increase in the ripple frequency.

The schematic shown in Figure 1 is that of a half-wave voltage doubler. Close examination and study of the schematic will reveal that the doubler is in fact made up of two half-wave voltage rectifiers. C1 and CR1 make up one rectifier and C2 and CR2 the other.

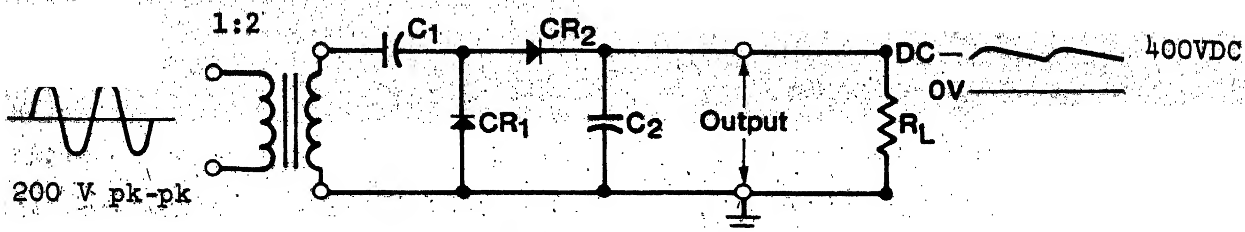


figure 1

HALF-WAVE VOLTAGE DOUBLER

When the top of the secondary winding of the transformer is negative, CR1 is forward biased, allowing C1 to charge to the peak value of the input voltage or 200 volts. When the top of the secondary winding of the transformer becomes positive, CR2 is forward biased and CR1 is reverse biased. At this time a series circuit exists consisting of C1, CR2, C2 and the secondary of the transformer. The secondary voltage of the transformer now series aids the voltage on C1 and results in a pulsating DC voltage of 400 volts as shown by the wave-form.

If you do not understand how a half-wave voltage doubler works after studying the schematic in Figure 1 and reading the explanation, you should consider an alternate mode of instruction. This lesson is also covered by narrative, programmed instruction, and tape/slide.

Figure 2 shows the schematic for a half-wave voltage tripler.

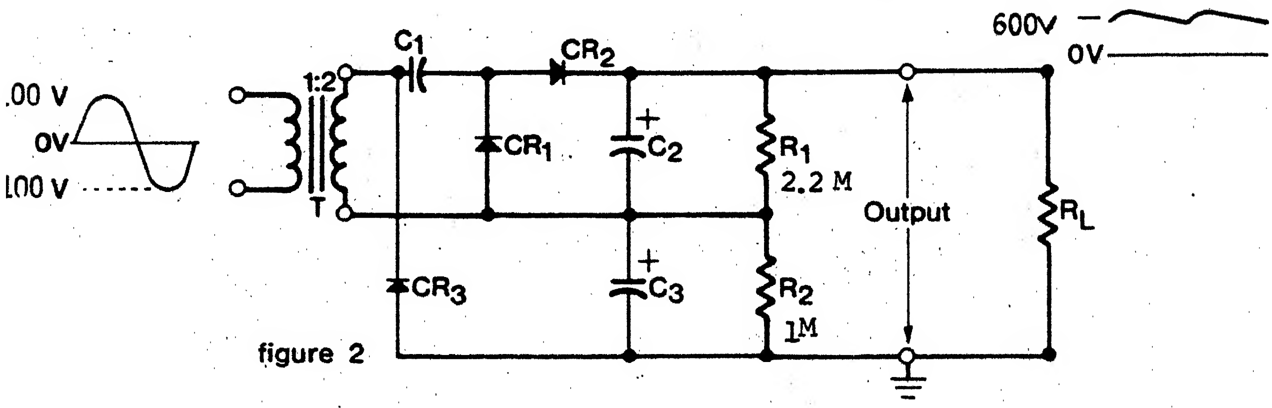


figure 2

HALF-WAVE VOLTAGE TRIPLER

The circuitry for the tripler is identical with that of the doubler except for the addition of C3, CR3, and R2. Considered separately, these components function as a half-wave rectifier. When the top of the secondary of the transformer is negative, CR3 is forward biased and functions as a closed switch. This allows both C1 and C3 to charge to a peak voltage of 200 volts. When the top of the transformer secondary is positive, C2 is charged to 400 volts as a result of the voltage doubling of the transformer secondary and C1. C2 and C3 now function as series aiding capacitors and discharge with a resultant voltage of 600 volts across the resistive load R_L. Note that the values of R1 and R2 are proportional to the voltages of C2 and C3, or in this case, a 2 to 1 ratio. Study the schematic to make sure you understand how the voltage tripler works.

The schematic shown in Figure 3 is that of a full-wave voltage doubler.

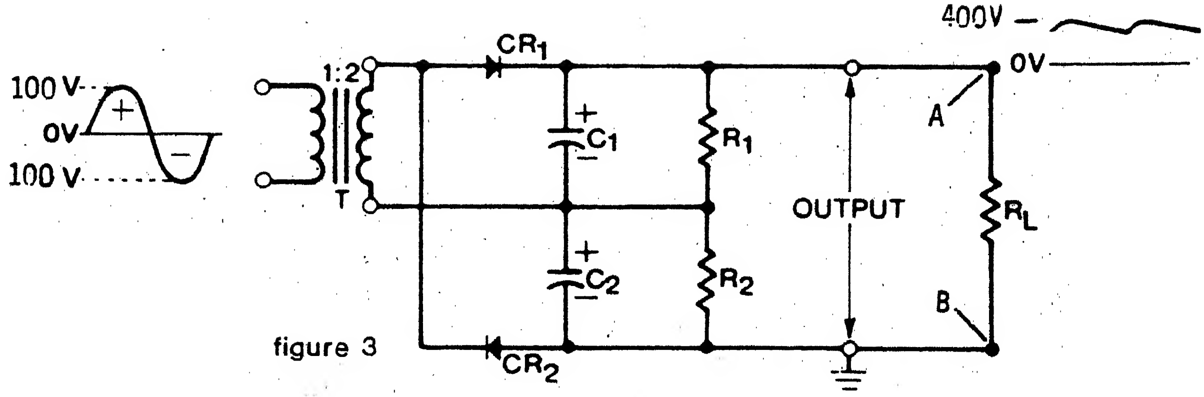


figure 3

FULL-WAVE VOLTAGE DOUBLER

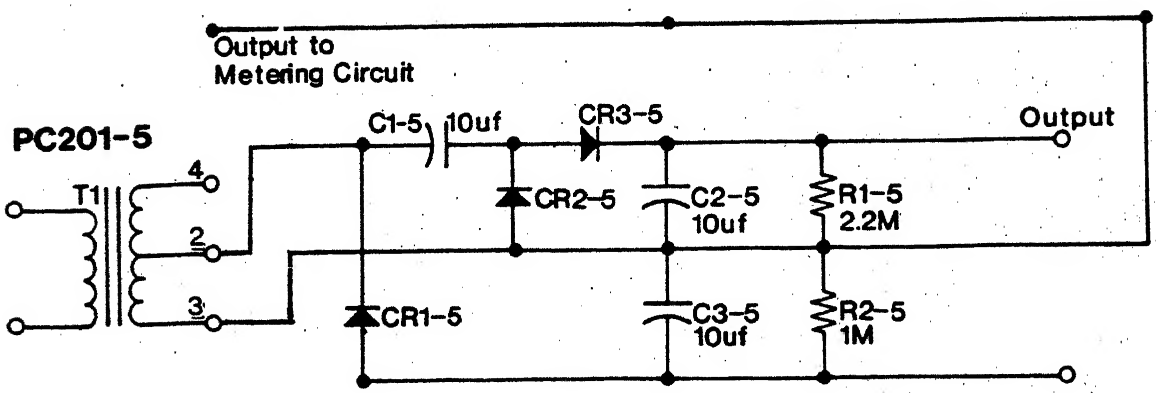
When you examine the schematic you see that the circuit is in fact made up of two half-wave rectifiers. These rectifiers function as series aiding except in a slightly different way. During the alternation when the secondary of the transformer is positive at the top, capacitor C1 charges to 200 volts through CR1. Then, when the transformer secondary is negative at the top, C2 charges to 200 volts through CR2. R1 and R2 are equal value balancing resistors which stabilize the charges of the two capacitors. Resistive load R_L is connected across C1 and C2 so that it receives the total charge of both capacitors. The output voltage is +400 volts when measured at the top of R_L or point "A" with respect to point "B". If the output is measured at the bottom of R_L it is -400 V. Either way the output is twice the peak value of the AC secondary voltage. As you can see the possibilities for voltage multiplication are almost limitless.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 1

Voltage Multipliers

USING THE SCHEMATIC DIAGRAM SHOWN BELOW, ANSWER QUESTIONS 1 THROUGH 7.



1. Select the correct input voltage to the multiplier.

   a. AC
   b. DC
   c. Rectified AC
   d. Rectified DC

2. When voltages are increased through the use of voltage multipliers, current ______________________.
   increases, decreases, remains the same

   a. increases
   b. decreases
   c. remains the same

3. What polarity of the voltage observed at terminal 2 of T1 would cause C1-5 to charge?

   a. Positive
   b. Negative

4. Which component charges to twice the peak value of the secondary (pins 2-3) voltage?

   a. C1-5
   b. C2-5
   c. C3-5

5. What is the ratio of the voltage across C3-5 to the voltage across C2-5?

   a. Twice
   b. One-third
   c. One-half
   d. Three times

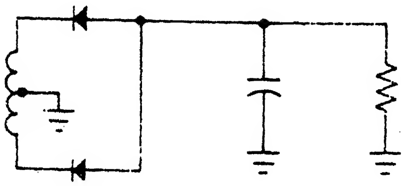
6. Select the correct statement which will determine when CR3-5 will conduct.

   a. CR1-5 is conducting.
   b. CR2-5 is conducting.
   c. C2 -5is discharging.
   d. Pin 2 of T1 is positive.

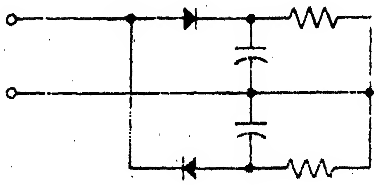
7. What is happening in the circuit when C1-5 is discharging. The voltage across:

   a. C2-5 will double.
   b. C3-5 will double.
   c. The output will double.
   d. C1-5 will double.

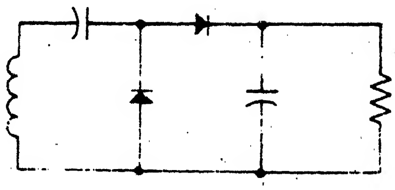
REFER TO THE SCHEMATIC DIAGRAMS BELOW TO ANSWER QUESTIONS 8 AND 9.



a



b



c

8. Which schematic diagram represents a half-wave voltage doubler?

   a.
   b.
   c.

9. Which diagram represents a full-wave voltage doubler?

   a.
   b.
   c.

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

INFORMATION SHEET
LESSON 1

Fluke Digital Multimeter

In your previous experiments, when voltage or resistance was measured, a VOM was used. It is a very handy and common instrument for this purpose, but it has some disadvantages. A VOM's indication will vary from user to user. When taking a reading with the VOM, the angle at which you view the meter will make a difference in the interpretation of the reading. This viewing angle difference is called parallax error.

Another problem affecting the accuracy of a meter is the number of units represented by each graduation on the meter face. In some cases the distance between graduations could stand for hundreds of units of measurement. A good example of this is the left hand portion of the resistance scale where there is as much as 1000 ohms represented in 1/8 inch of space.

A more accurate instrument for measuring voltages, and resistances, is the digital multimeter (DMM). It uses a digital readout that does away with parallax error and the problem of the number of units represented by the graduations. The DMM also has a high input impedance (approximately 10 megohms), which minimizes loading effects caused by standard VOM's. This information sheet will describe the functions of the controls and give examples of how to take voltage and resistance measurements. We will use, in this school, the CCUH-8000A Digital Multimeter as a representative digital multimeter.

ENERGIZING DIGITAL MULTIMETER:

Refer to Figure 1 for the locations of controls discussed in the following paragraphs.

1. Attach the power cord to the POWER input connector. (1)

2. Depress green POWER ON switch (2) to the "on" position and ensure that the READ OUT (3) is lighted.

You are now ready to use the digital multimeter for voltage and resistance measurements.

VOLTAGE MEASUREMENTS

1. The CCUH-8000A is capable of measuring AC and DC voltages up to 2000 volts. The CCUH-8000A can have up to 1200 VDC or 1200 VRMS on all 5 DC scales and up to 1200 VRMS on the 20, 200 or 1200 V ranges and 500 VRMS on the 200 MV and 2V ranges. These voltages are overrange voltages and can be applied continually without damage to the unit. With the use of a special high voltage probe, the voltage range can be extended up to 40 kilovolts.

2. To measure voltage on the CCUH-8000A, first press either the DCV (4) or ACV (5) function switch. This places the instrument in either the DC voltage mode or the AC voltage mode.

3. Select the full scale voltage range desired (200MV, 2, 20, 200, or 1200) pressing the correct RANGE switch (6).

4. Connect the voltage to be measured to the INPUT terminals (7). The DC range has an automatic POLARITY INDICATOR (8) that indicates whether the DC voltage beirg measured is positive or negative.

5. The display is a direct readout of the measured voltage with the necessary polarity marks and the decimal point placed in the correct position.

RESISTANCE MEASUREMENTS:

1. The CCUH-8000A will measure resistances in six full scale ranges of 200 ohms, 2K, 20K, 200K, 2000K and 20 megohms.

2. Select the kilohms function switch (9) for measuring resistances between 0 and 2000 kilohms and use the 20 megohms switch (10) for measuring resistances between 2 and 20 megohms.

3. In the kilohms position select the desired full scale range (200 ohms, 2K, 20K, 200K, or 2000K) by pressing corresponding RANGE switch (6). In the 20 megohms position, the range is fixed and is independent of the range switches.

4. Connect the resistance to be measured to the INPUT TERMINALS (7).

5. The display presented is a direct readout of the resistance value with the decimal point in the correct position.

With both the voltage and resistance functions, there is an overrange indication. The display will blink and indicate a full scale reading when the measurement being taken is beyond the capabilities of the range being used. The presence of an overrange indication does not necessarily mean that the instrument is being exposed to a "damaging" input condition. To rectify the overrange condition simply shift to the next higher range until the indicator goes out.

DIODE TEST MEASUREMENTS:

To perform a diode or transistor junction resistance test with a Fluke 8000A/BU, place the DMM in the "KΩ" function with a range selection of "2".

NOTE: There is a diode symbol above the "KΩ" and "2" switches.

The CCUH-8000A Digital Multimeter has many applications. For explanations concerning transistor testing and current applications, as well as other applications, refer to the Technical Manual for the CCUH-8000A Digital Multimeter.

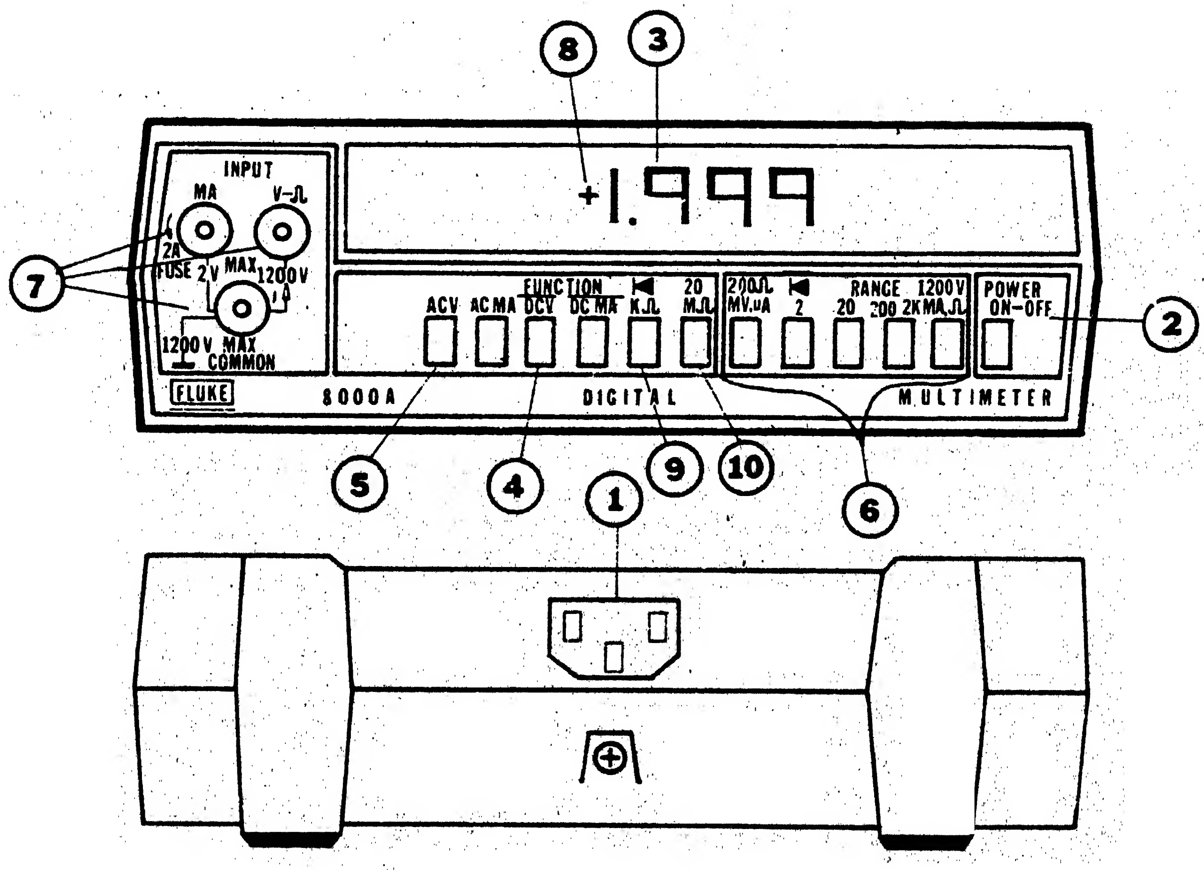


Figure 1

DIGITAL MULTIMETER

INFORMATION SHEET
LESSON 1

Ballantine Digital Multimeter

In your previous experiments when voltage or resistance was measured, a VOM was used. It is a very handy and common instrument for this purpose, but it has some disadvantages. A VOM's indication will vary from user to user. When taking a reading with the VOM, the angle at which you view the meter will make a difference in the interpretation of the reading. This viewing angle difference is called parallax error.

Another problem affecting the accuracy of a meter is the number of units represented by each graduation on the meter face. In some cases the distance between graduations could stand for hundreds of units of measurement. A good example of this is the left hand portion of the resistance scale where there is as much as 1000 ohms represented in 1/8 inch of space.

A more accurate instrument for measuring voltage and resistances is the digital multimeter (DMM). It uses a digital readout that does away with parallax error and the problem of the number of units represented by the graduations. The DMM also has a high input impedance (approximately 10 megohms), which minimizes loading effects caused by standard VOM's. This information sheet will describe the functions of the controls and give examples of how to take voltage and resistance measurements. We will use the Ballantine Model 3028B digital multimeter as a representative digital multimeter.

ENERGIZING THE BALLANTINE MODEL 3028B DMM.

Refer to Figure 1 for the locations of controls discussed in the following paragraphs.

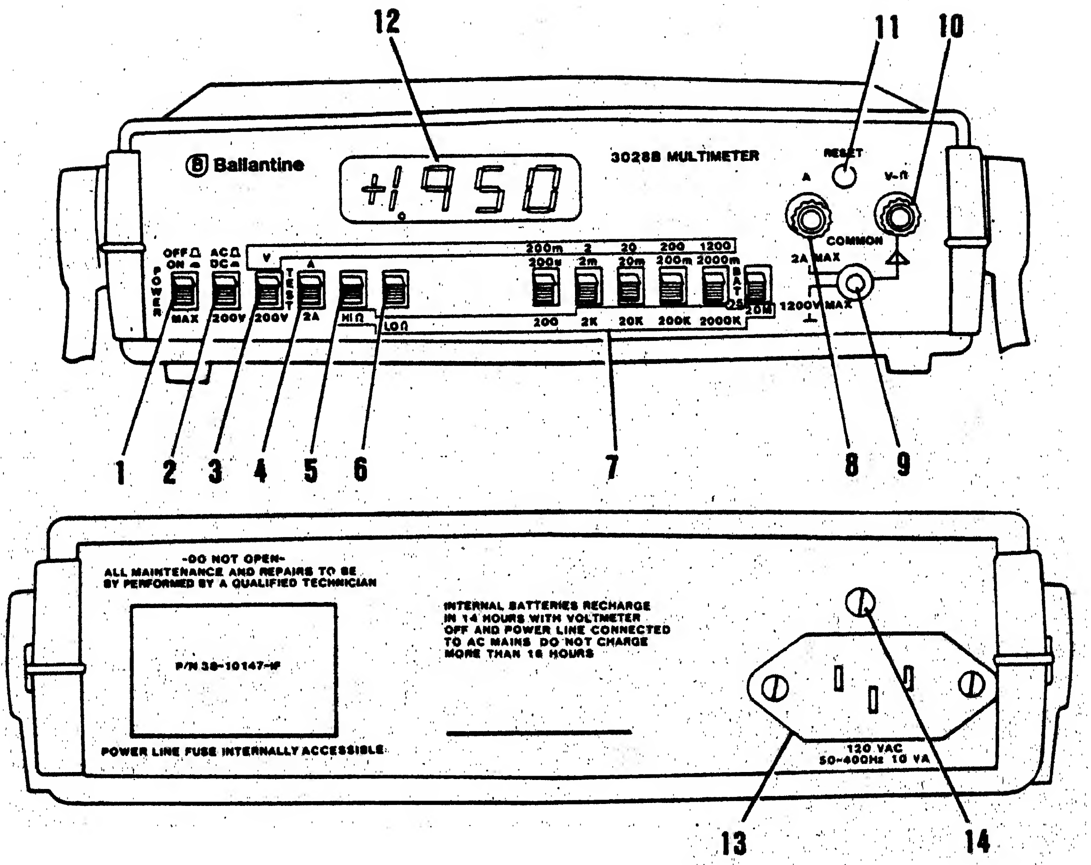
1. Attach the power cord to the POWER input connector.(13)
2. Depress the white POWER ON switch (1) at the extreme left of the front panel to the "on" position and ensure that the READ OUT (12) is lighted.

You are now ready to use the digital multimeter for voltage and resistance measurements.

VOLTAGE MEASUREMENTS

1. The Ballantine Model 3028B DMM is capable of measuring AC voltages to 1200 VRMS and DC voltages to 1200 VDC.

CAUTION: A flashing display indicates an overvoltage condition exists (the voltage applied is greater than the range setting of the meter). Switch to the next higher voltage range on the meter.



MODEL 3028B, CONTROLS, INDICATORS, AND CONNECTORS

2. The second switch (2) from the left on the front panel selects either the AC or DC Function dependent upon whether the voltage to be measured is an AC or a DC voltage.

3. The next 4 switches from the left (3), (4), (5) and (6) are for the voltage, current and resistance functions. The current function will be not discussed in this information sheet. The resistance function will be discussed later.

4. To measure voltage depress the V switch (3).

5. Select the full scale voltage range desired (7). Notice the three colors, gray for voltage, black for current and orange for resistance. The voltage range switches have a range of 200mv, 2v, 20v, 200v, and 1200v.

6. Connect the voltage to be measured to the input terminals (9) and (10). The DC range has an automatic polarity indicator that denotes whether the measured voltage is positive or negative.

7. The display is a direct readout of the measured voltage with the polarity marks and the decimal point placed in the correct position.

<u>RESISTANCE MEASUREMENTS</u>

1. The Ballantine model 3028B DMM will measure resistances in six full scale ranges: 200 ohms, 2k, 20k, 200k, 2000k and 20 megohms.

2. Notice the two ohms function switches Hi Ω (5) and Lo Ω (6). The Lo Ω function switch is advantageous when measuring circuit resistances in circuits using semiconductor devices. The voltage available with the Lo Ω function switch depressed is less than 180mv which is not sufficient to forward bias silicon transistor junctions but may be sufficient to forward bias some germanium transistor junctions. DO NOT USE THIS FUNCTION TO MEASURE THE FRONT TO BACK RATIO ON INDIVIDUAL DIODES OR TRANSISTOR JUNCTIONS.

3. The voltage available with the Hi Ω function switch depressed is 1.8v which is sufficient to test the front to back ratio of diodes and transistor junctions and to measure larger resistance values.

4. Connect the resistance to be measured to the input terminals (9) and (10).

5. The display is a direct readout of the resistance value with the decimal point in the correct position.

6. The resistance ranges also have an overrange indication. If the resistance is greater than the range switch which has been selected, the display will blink on and off and appear to count from a low number to a high number. The display will not stop on any number but keep on counting in a repetitious manner.

INFORMATION SHEET
FOR
B+K Model 1535 Dual Trace Oscilloscope

The B+K Model 1535 Dual Trace Oscilloscope is similar in its operation to the NIDA 207 Oscilloscope with very few differences. As with all test equipment caution should be observed in its use; and you should familiarize yourself with the controls prior to attempting to use it. If you are uncertain of the safety precautions to be observed, or of the capabilities and limitations of the 1535 Dual Trace Oscilloscope, contact your learning center instructor before you use it. The purpose of this information sheet is to familiarize you with the controls and initial set-up of the scope in order to obtain a sweep. Refer to Figure 1 while reading this information sheet.

GENERAL CONTROLS:

1. MODE Switch.
   Five position lever switch; selects the basic operating modes of the Oscilloscope.

   CH "A" — Only the input signal to channel "A" is displayed as a single trace.

   CH "B" — Only the input signal to channel "B" is displayed as a single trace.

   DUAL — In Dual Trace operation; both the channel "A" and channel "B" input signals are displayed on two separate traces.

   ADD — The waveforms from the channel "A" and channel "B" inputs are added and the sum is displayed as a single trace. When the channel "B" position control is pulled (PULL INVERT), the waveform from channel "B" is subtracted from the channel "A" waveform and the difference is displayed as a single trace.

   X-Y — X-Y operation. The channel "A" input signal produces vertical deflection (Y axis). The channel "B" input signal produces horizontal deflection (X axis).

2. TRACE ROTATION Control

   This control electrically rotates the trace to align it with the horizontal reference line. It is not normally used after the initial adjustment.

3. ASTIG Adjustment

   Astigmatism adjustment provides optimum spot roundness when used in conjunction with the FOCUS and INTENSITY controls. This control is not normally used after the initial adjustment.

4. Cathode Ray Tube (CRT)

The screen on which the waveforms are viewed.

5. SCALE

This 8X10 cm graticule provides calibration marks for voltage (vertical) and time (horizontal) measurements. Scale illumination is variable.

6. FOCUS Control

7. INTENSITY Control

Adjusts brightness of the trace.

8. POWER SCALE ILLUM Control

Fully CCW rotation of this control (OFF position) turns off the oscilloscope. CW rotation turns on the oscilloscope. Further CW rotation of this control increases the illumination level of the scale.

9. PILOT LIGHT

Glows when the oscilloscope is turned on.

10. NORM - CHOP Switch

Push button switch operates in conjunction with SOURCE switch (24) to provide automatic or manual selection of alternate or chop method of dual trace sweep generation. Thus:

When the source switch is in the ALT position:
Alternate sweep is selected regardless of sweep time; The NORM - CHOP switch has no effect.

When the source switch is in any position except ALT and the NORM - CHOP switch is in the NORM (out position):
Alternate sweep is automatically selected at all sweep times of .5 ms/cm and faster; chop sweep is automatically selected at all sweep times of 1 ms/cm and slower.

When the NORM - CHOP switch is in the CHOP position (in position), CHOP sweep is selected regardless of sweep time.

11. ◀▶ POSITION Control

Adjusts the horizontal position of the traces (both traces when operated in the dual trace mode). Push-pull switch selects 5X magnification when pulled out (PULL 5X MAG); normal when pushed in.

12. Sweep Time UNCAL Indicator

Glows when sweep time VARIABLE control (14) is not set to the CAL position. It reminds the user that the time measurements are not calibrated.

13. SWEEP TIME/CM Switch

Horizontal coarse sweep time selector. Selects calibrated sweep times of 0.1 usec/cm to 0.5 sec/cm in 21 steps. When VARIABLE control (14) is set to the CAL position (fully CW).

14. Sweep Time VARIABLE Control

Fine sweep time adjustment. Normally used in the CAL position (fully CW).

15. HOLD OFF Control

Adjusts hold off time (trigger inhibit period beyond sweep duration). Normally used when a series of pulses appears periodically to prevent double images from appearing on the scope.

16. EXT TRIG Jack

Input terminal for an external trigger signal.

17. CAL 1 kHz ⎍ 0 1V P/P terminal

Provides a calibrated 1 kHz, 0.1 volt peak-to-peak square wave input signal. Used for calibration of the vertical amplifier attenuators and to check the calibration of the probes used with the oscilloscope.

18. ⏚ Terminal/Binding Post

Earth and chassis ground.

TRIGGERING CONTROLS

19. RESET Button

When triggering MODE switch (22) is in the SINGLE mode, pushing the RESET button initiates a single sweep which will begin when the next sync trigger occurs.

20. READY/TRIG'D Indicator

In the SINGLE triggering mode (22), the indicator lights when RESET button (19) is pressed and goes off when the sweep is completed. In the NORM, AUTO and FIX triggering modes, the indicator lights for the duration of the triggered sweep; shows when LEVEL control (21) is properly set to obtain triggering.

21. LEVEL Control

Sync level adjustment determines points on the waveform slope where the sweep starts; (-) equals the most negative point of triggering and (+) equals the most positive point of triggering. Push-pull switch selects positive or negative slope (PULL SLOPE NEG). Sweep is triggered on the positive going slope of the sync waveform with the switch pushed in; on the negative going slope of the sync waveform when pulled out.

22. Triggering MODE Switch

A four position level switch that selects the triggering mode.

SINGLE	Enables RESET switch (19) for triggered single sweep operation.
NORM	Normal triggered sweep operation.
AUTO	Triggered sweep operation when trigger signal is present, automatically generates a sweep (free runs) in the absence of a trigger signal.
FIX	Same as automatic mode, except trigger threshold is automatically fixed at the center of the trigger signal regardless of the setting of the LEVEL control (21).

23. COUPLING Switch

A five position level switch that selects coupling for the sync trigger signal.

AC	Trigger is AC coupled, 10Hz to 40MHz.
LF Rej	Trigger signals below 10 kHz are attenuated.
HF Rej	Trigger signals above 100 kHz are attenuated.

VIDEO — Sync pulses of a composite video signal are used to trigger the sweep; the vertical sync pulses (frame) are automatically selected for sweep times of 0.5 sec/cm to 0.1 msec/cm, and horizontal sync pulses (lines) are automatically selected for sweep times of 50 usec/cm to .1 usec/cm.

DC — Trigger is DC coupled.

24. SOURCE Switch

A five position lever switch that selects the sync trigger source:

ALT — When the MODE switch (1) is in the CH "A" or ADD modes, the sweep is triggered by a signal to the channel "A" INPUT jack (34).

When MODE switch is in the CH "B" mode, sweep is triggered by a signal to the channel "B" INPUT jack (27).

When MODE switch is in the DUAL mode, channel "A" trace is triggered by the channel "A" input signal and the channel "B" trace is triggered by the channel "B" input signal.

CH "A" — The sweep is triggered by a signal to the channel "A" INPUT jack regardless of MODE switch (1) selection.

CH "B" — The sweep is triggered by a signal to the channel "B" INPUT jack regardless of MODE switch (1) selection.

EXT Sync Position

EXT 1 — Sweep is triggered by a signal at the EXT TRIG jack (16). Trigger is unattenuated.

EXT 1/10 — Sweep is triggered by a signal at the EXT TRIG jack (16). Trigger is attenuated by a factor of 10.

CHANNEL "B" CONTROLS

25. POSITION Control

Vertical position adjustment for the channel "B" trace. Becomes the horizontal position adjustment when the MODE switch (1) is in the X-Y position. Push-pull switch selects normal or inverted polarity of the channel "B" display (PULL INVERT).

26. UNCAL Indicator

Glows when the channel "B" VARIABLE control (30) is not set to the CAL position. Reminds user that the channel "B" measurements are not calibrated.

27. INPUT Jack

Vertical input jack of channel "B". Jack becomes the external horizontal input when MODE switch (1) is in the X-Y position.

28. Channel "B" AC - GND - DC Switch

AC Blocks the DC component of the input signal.

GND Opens the signal path and grounds the input signal to the vertical amplifier. This provides a zero signal base line, which can be used as a reference when performing DC measurements.

DC Direct input of the AC and DC components of the input signal.

29. VOLTS/CM Switch

Vertical attenuator for channel "B" which provides step adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 12 steps from 2 mv to 10 volts per cm when the VARIABLE control (22) is set to the CAL position. This control adjusts horizontal sensitivity when MODE switch (1) is in the X-Y position.

30. VARIABLE Control

Vertical attenuator adjustment provides fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated. This control becomes the fine horizontal gain control when the MODE switch (1) is in the X-Y position.

CHANNEL "A" CONTROLS

31. VOLTS/CM Switch

Vertical attenuator for channel "A" which provides coarse adjustment of the vertical sensitivity. Vertical sensitivity is calibrated in 12 steps from 2 mv to 10 volts per cm when the VARIABLE control (32) is set to the CAL position.

32. VARIABLE Control

Vertical attenuator adjustment provides fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated

33. Channel "A" AC - GND - DC Switch

AC Blocks the DC component of the input signal.

GND Opens the signal path and grounds the input signal to the vertical amplifier. This provides a zero signal base line, which can be used as a reference when performing DC measurements.

DC Direct input of the AC and DC components of the input signal.

34. INPUT Jack

Vertical input jack of channel "A".

35. UNCAL Indicator

Glows when the channel "A" VARIABLE control (32) is not set to the CAL position. Reminds the user that the channel "A" measurements are not calibrated.

36. POSITION Control

Vertical position adjustment for the channel "A" trace.

CAUTION

Never allow a small spot of high brilliance to remain stationary on the screen of any oscilloscope for more than a few seconds. The screen may become permanently burned. Reduce intensity or keep the spot moving by causing it to sweep. ALWAYS turn the intensity down if you are not going to be using the scope for any length of time.

Never cover the ventilating holes in the sides of the oscilloscope, as this will increase the operating temperature inside of the case.

INITIAL STARTING PROCEDURES

Until you familiarize yourself with the use of all controls, the following procedure may be used to standardize the initial setting of controls as a reference point and to obtain a trace on the CRT in preparation for waveform observation:

1. Set POWER SCALE ILLUM control (8) to OFF (fully CCW).
2. Connect power cord (40) to a 120 volt, 50/60 Hz outlet.
3. Set CH "A" POSITION control (36), CH "B" POSITION control (25) and ◀▶ POSITION (11) to the centers of their ranges.
4. Set CH "A" AC - GND - DC switch (33) and CH "B" AC - GND - DC switch to the GND positions.
5. Set the MODE switch (1) to the DUAL position for dual trace operation.
6. Set SWEEP TIME/CM switch (13) to .1 ms position.
7. Set triggering MODE switch (22) to AUTO.
8. Set SOURCE switch (24) to ALT.
9. Turn on POWER SCALE ILLUM control (8) CW. The pilot light (9) will glow. Adjust control for the desired amount of scale illumination.
10. Wait a few seconds for the CRT to warm up. Two traces should appear.
11. If no trace appears, increase the intensity control (7) until a trace is easily observed.
12. Adjust FOCUS control (6) and INTENSITY control (7) for the thinnest, sharpest trace.

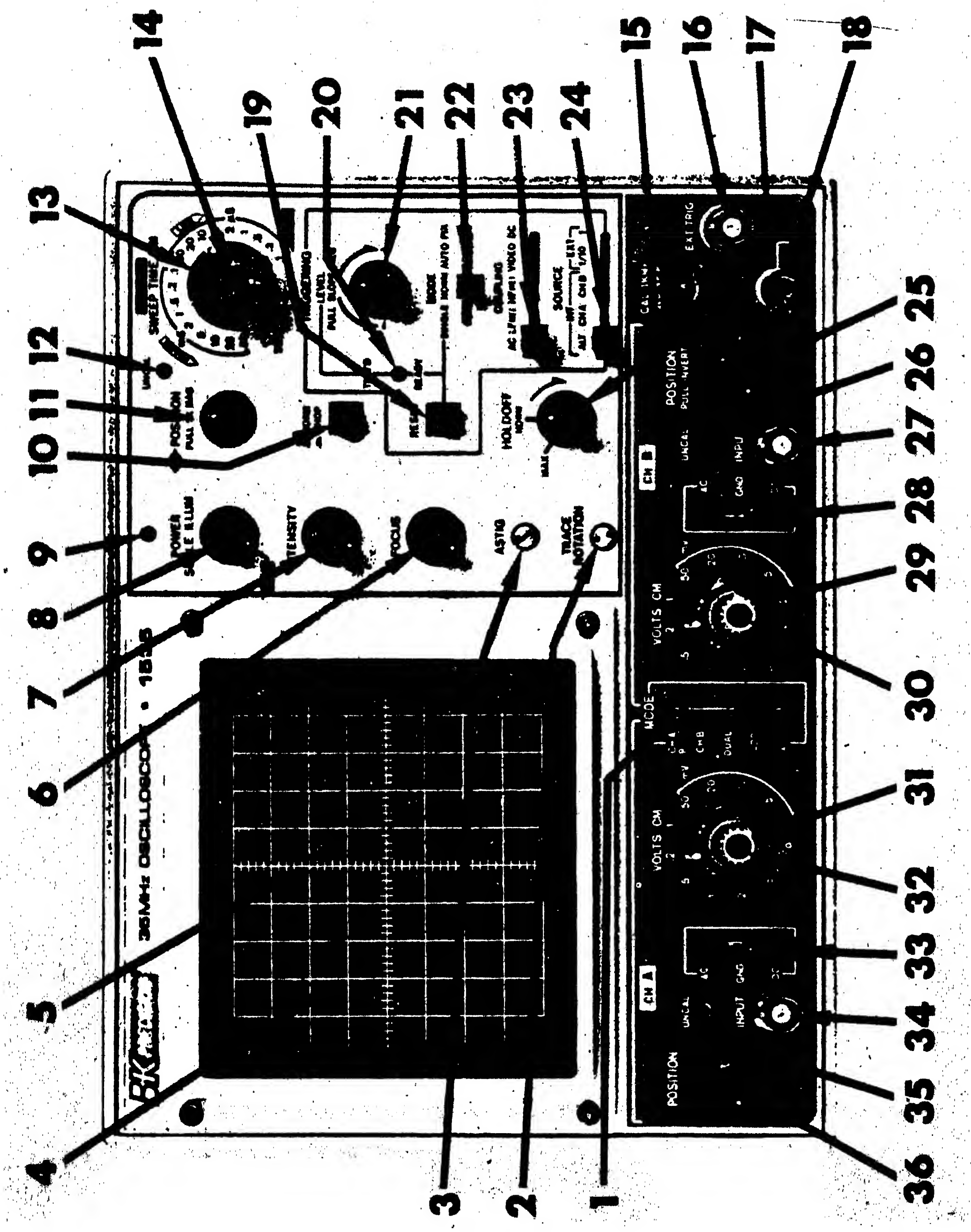


Fig. 1. Front panel controls and indicators.

JOB PROGRAM
FOR
LESSON I

Voltage Multipliers

DO NOT ATTEMPT THIS JOB PROGRAM UNTIL
YOU COMPLETE THE INSTRUCTIONAL PROGRAM FOR LESSON 1

INTRODUCTION

This job program is designed to provide you with "hands on" experience measuring voltages in voltage multiplier circuits. The program will also give you experience using the digital multimeter. Completion of the job program will give you a better understanding of voltage multipliers and help prepare you for the lesson test.

SAFETY PRECAUTIONS:

Observe all standard safety precautions. Beware of all exposed connections, an energized circuit may have dangerous voltages in it.

EQUIPMENT AND MATERIALS

1. NIDA 201 Power Supply
2. PC201-5 Printed Circuit Card
3. Oscilloscope -Single Trace
4. Digital Multimeter
5. 10X Probe (1)
6. NIDA 201 Power Supply Instruction Manual
7. Information Sheet Thirty-1
8. Schematic diagram PC201-5, Voltage Tripler

PROCEDURES

1. Energize and set the oscilloscope for single trace operation with an INTERNAL TRIGGER input.

2. Connect the 10X probe to CHANNEL "A" of the oscilloscope.

3. Energize and set the digital multimeter to read "DCV" on the "200" volt range.

4. Remove the top cover from the NIDA 201 Power Supply.

5. Install the PC201-5 card in the NIDA 201 Power Supply.

6. Plug in and energize the NIDA 201.

7. Push the DC/AC switch on the oscilloscope to "DC". Position the trace on the center line as a reference for measuring DC level.

8. Refer to schematic diagram fold out at the end of this job program (pg 40).

9. All measurements will be made with reference to circuit common.

10. Connect the 10X probe to pin 2 of PC201-5. Observe and record in Figure 1 the waveform observed.

    a. The peak voltage of this waveform is _______ V_{pk}.

    b. The RMS value of this waveform is _______ VAC.

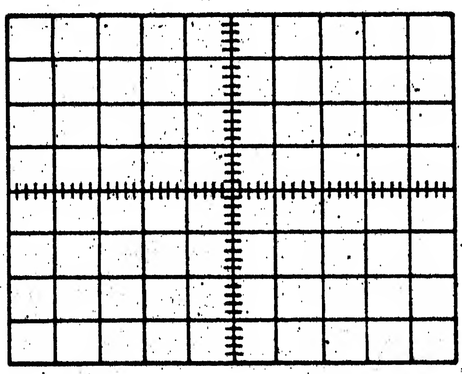


Figure 1

11. Using the oscilloscope in the "AC" position, observe and record in Figure 2 the voltage between the top of R1-5 and circuit common.

    a. What is the ripple frequency of the output voltage?________

    b. Is the multiplier a half-wave or a full-wave multiplier?_____

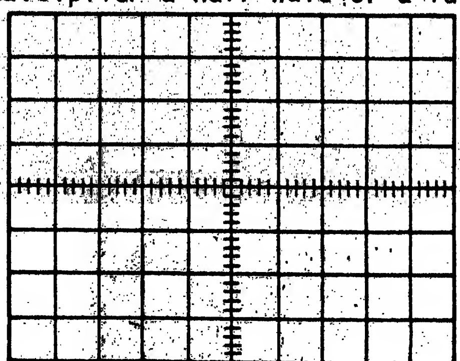


Figure 2

12. Using the digital multimeter measure and record the voltage between the top of R1-5 and circuit common.

    This voltage is ________ VDC.

13. This voltage is approximately ________ the peak input voltage.

    a. one-third
    b. twice
    c. three times
    d. the same as

14. Using the digital multimeter measure and record the voltage across C2-5.

    This voltage is ________ VDC.

15. This voltage is approximately __________ the output voltage measured in step 12.

    a. one-third
    b. twice
    c. two-thirds
    d. the same as

16. Using the digital multimeter measure and record the voltage across C3-5.

    This voltage is __________ VDC.

17. This voltage is approximately _______________ the output voltage measured in step 12.

    a. two-thirds
    b. three times
    c. the same as
    d. one-third

18. Using the color code, compare the resistance value of R1-5 to R2-5.

    a. What is the ratio of R1-5 to R2-5?

19. List the components in the schematic diagram of PCB 201-5 that operate as a voltage doubler ______________________________

20. List the components in the schematic diagram of PCB 201-5 that operate as a half-wave rectifier ______________________________

21. What is the purpose of R1-5 and R2-5? ______________________________
____

22. Observe the front panel voltmeter of the PC201 power supply.

   a. What is the maximum range of the voltmeter?__________

   b. What value of voltage is being measured by the meter?_______

   c. What would happen to the meter movement if the full tripler multiplier voltage were applied to the meter?________________________
   ____

23. From the above it should be noted that the meter is measuring only one third of the tripler output.

24. Using the digital multimeter, measure the voltage at pin 7 to common and pin 18 to common of PC201-5 to verify your observations made in steps 22 and 23. This voltage is__________VDC.

NOTE: The discharge time of C2-5 and C3-5 is about 30 seconds which means that the printed circuit card PC201-5 should not be removed from the power supply until the power has been turned off for at least 45 seconds after you have completed this job program.

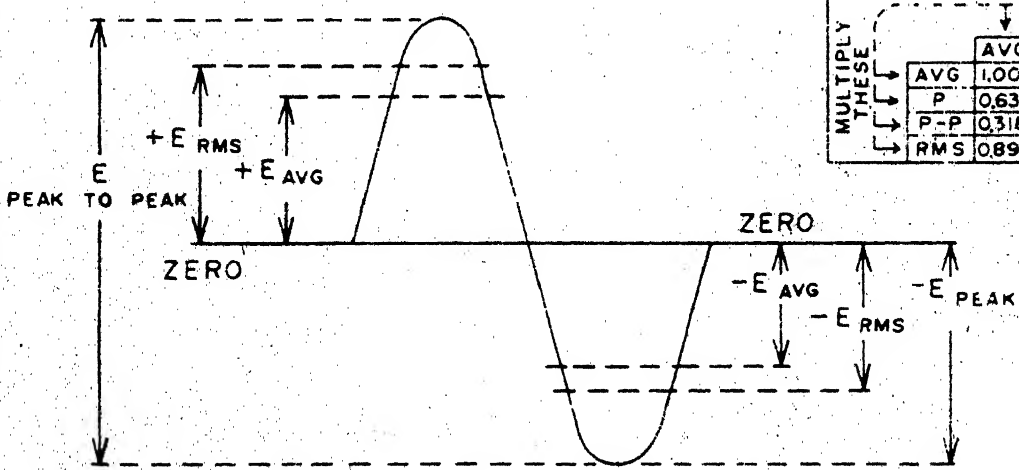
CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS, OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

INFORMATION SHEET
LESSON 1

Conversion of AC and DC Voltages

INTRODUCTION:

Many times in the study of electronics it becomes nescessary to convert AC voltages to DC, effective (RMS) and average voltages to peak and vice versa. This information sheet is not designed to explore the formulation of various mathematic constants but to give you these constants so you can commit them to memory since there are but a few. The average value of an AC sine wave is NOT always zero, but is a function of its reference. This portion of the information sheet will discuss the waveform in Figure 1. Let us assume that the effective RMS value is 115 VAC which is available from most electrical outlets, and is referenced at zero volts.



MULTIPLY THESE ↓ / TO OBTAIN THESE →	AVG	P	P-P	RMS
AVG	1.000	1.572	3.144	1.111
P	0.636	1.000	2.000	0.707
P-P	0.318	0.500	1.000	0.353
RMS	0.899	1.414	2.828	1.000

Average, RMS, and Peak Voltage Relationships of a Sine Wave

Figure 1

Notice that in Figure 1 the sine wave goes from a peak positive to a peak negative in this case, so the average value of this peak to peak voltage is zero volts. The sine also goes from E eff. (RMS) positive to E eff. (RMS) negative so the average of this portion of the sine wave is again zero volts. The same holds true when analyzing the average values in Figure 1. The formulas therefore are applied to only one-half, the positive or the negative portions of a cycle or period.

1. When the effective (RMS) value of an AC waveform is given; to find the peak value multiply by 1.414.

   a. This converts 115 VAC effective (RMS) to 162.6 volts peak.
   b. To convert to peak to peak values multiply the effective (RMS) values by 2.828.
   c. If you have already found the peak value simply multiply by 2.

NOTE: The effective (RMS) value of an AC waveform is the amount of AC required to produce the same heating effect as an equal amount of DC.

2. When the effective value of an AC waveform is given; to find the average value multiply by 0.9.

   a. The 115 VAC effective (RMS) value given, when multiplied by 0.9 will convert to 103.5 volts average.

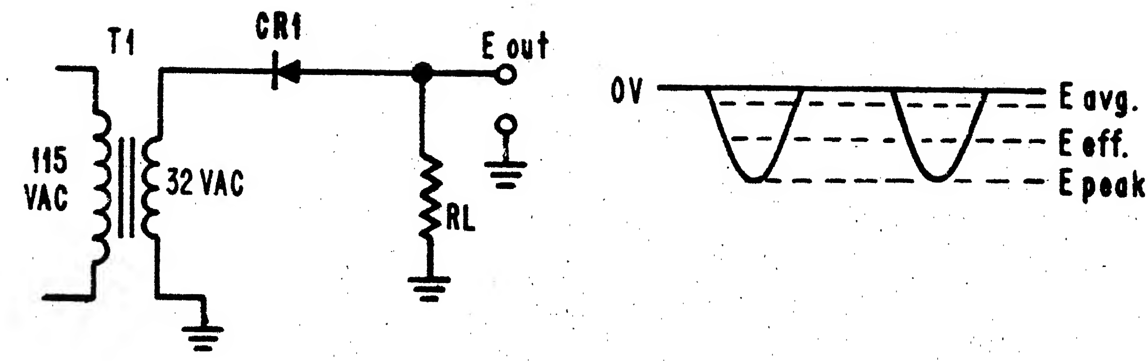
3. When the average value of an AC waveform is given; to find the peak value, multiply by 1.572.

   a. The 103.5 volt average from statement 2a above when multiplied by 1.572 will convert to 162.7 volts peak.

4. When the peak value of an AC waveform is given; to find the effective (RMS) value multiply by 0.707.

   a. The 162.6 volts peak in statement 1a above, when multiplied by 0.707 will convert to 114.958 volts effective (RMS).
   b. 0.707 can be found by taking the reciprocal of 1.414 or 1/1.414 = 0.707.
   c. To convert the effective value back to the peak value use the formula in statement 1a.

Refer to Figure 2 for the following discussion on the output of a half-wave rectifier (unfiltered) power supply.



HALF WAVE RECTIFIER (UNFILTERED) POWER SUPPLY

Figure 2

5. The average DC value of a half-wave rectifier (unfiltered) AC voltage is 0.318 multiplied by E peak.

   a. E peak is equal to E eff. X 1.414 or 45.2 V.
   b. E avg. is equal to E peak X 0.318 or 14.4 V.
   c. E avg. is also equal to E eff. X 0.9 / 2 or 14.4 V.
   d. Division by 2 is necessary because only one alternation of the secondary voltage is being used.

Refer to Figure 3 for the following discussion on the output of a full-wave rectifier (unfiltered) power supply.

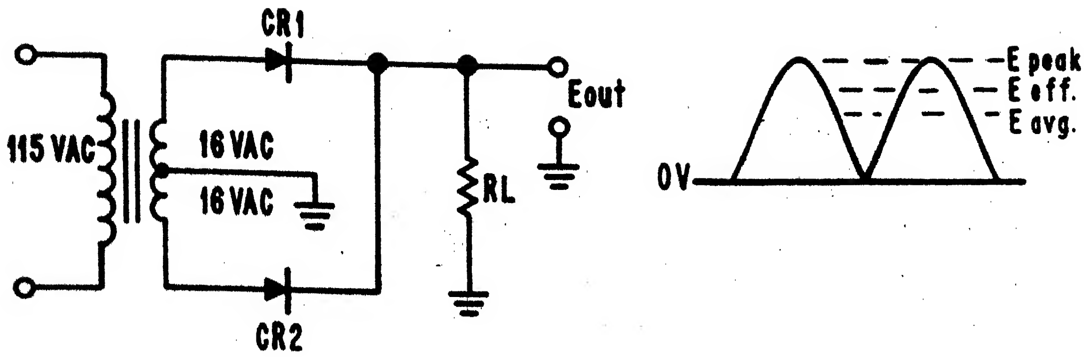


Figure 3
FULL WAVE RECTIFIER (UNFILTERED) POWER SUPPLY

NOTE: Compare the above circuit with the schematic diagram of the half-wave rectifier (unfiltered) power supply and notice the difference. In the half-wave the full secondary voltage is being used but in the full wave only one-half of the secondary voltage is being used at any instantaneous period of time. This will cause a higher peak voltage from the half-wave rectifier when compared to the peak output from the full-wave rectifier. The average DC value out will remain approximately the same, as you will notice when you have completed this information sheet.

6. The average DC value output from a full-wave rectifier (unfiltered) AC voltage is 0.636 times E peak.

   a. E peak is equal to E eff. X 1.414 = 22.6 VDC.
   b. E avg. is equal to E peak X 0.636 = 14.4 VDC.
   c. E avg. is also equal to E eff. X 0.9 = 14.4 VDC.
   d. Division by 2 is unnecessary because all of the waveform is being used.

NOTE: This information sheet was compiled because a multimeter, when using the AC position is calibrated to indicate the effective value of an AC waveform so to find average or peak values the above information is necessary, and the same multimeter when using the DC position will indicate the average value so again, to find the peak or effective values the above information is necessary.

INFORMATION SHEET
LESSON 1

Troubleshooting Power Supplies

Troubleshooting electronic circuits requires the application of skills and knowledges in a manner that is similar to solving a mystery novel, or "who done it" story. You must gather evidence and "clues" by physical methods. In electronics, this evidence gathering is accomplished by using your test equipment such as the oscilloscope and/or volt-ohm-milliammeter. When you have sufficient evidence, you use it in a logical, deductive manner to proceed from the known to the unknown. In a mystery, you determine the villain; in electronics you find the faulty component.

The following information is what you might call "hints for troubleshooting". These tidbits of information will aid you in analyzing the evidence you have at your disposal. They will help to remind you of significant relationships about certain facts. These proven aids will help to guide you to a logical conclusion.

What to look for:

1. When identical voltages are measured to common at two points in a circuit, the points are probably shorted together, or connected by a straight wire. See Figure 1.

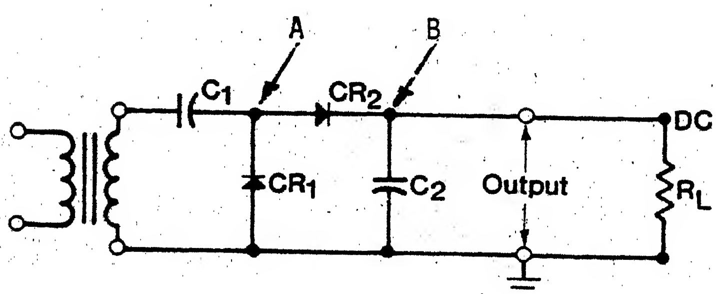


Figure 1

SYMPTOM

Voltage - "A" to ground equals
Voltage - "B" to ground

Conclusion: CR2 shorted
Confirm: Take resistance measurement across CR2 (be sure you remove power first)

2. The resistance of a connecting wire or foil on a printed circuit board is "Zero" ohms. See Figure 2.

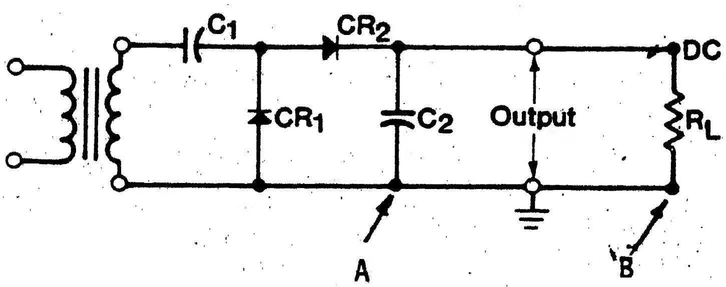


Figure 2

SYMPTOM

The resistance between points "A" and "B" is high.

Conclusion: The printed circuit board foil is open between point "A" and "B".

3. There are zero volts dropped across a component that does not have current through it. See Figure 3.

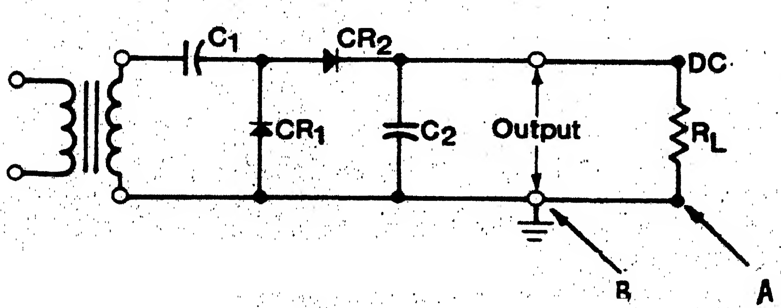


Figure 3

SYMPTOM

The voltage at point "A" is a high DC value.

Conclusion: R_L has no current through it. Open foil between points "A" and "B".

Confirm: Take resistance measurement between points "A" and "B".

OVERALL PERFORMANCE TEST INSTRUCTIONS

FOR

TROUBLESHOOTING PERFORMANCE TEST

INTRODUCTION:

Using the following six step troubleshooting procedure will aid you in determining which component is faulty. Depending upon the type of equipment you are troubleshooting some of the six steps may not be necessary and you should write "NA" in the blank if you think that this is the case. In the PC201-5 voltage multiplier, you will recall from the Job Program an output was taken from the top of R2-5 in order to protect the metering circuit. The actual output in practical voltage multipliers is taken across the two resistors so it is possible to indicate a proper voltage output on the front panel voltmeter in this case and still not have a proper output from the circuit. When measuring across a component in an energized circuit always connect the common lead first then use one hand to measure the voltage with the other probe.

EQUIPMENT:

1. NIDA 201 Power Supply
2. NIDA 201-5 Prefaulted Circuit Board
3. Oscilloscope-Single Trace
4. 10:1 Oscilloscope Probe
5. Digital Multimeter
6. Simpson 260 Multimeter
7. 1 Pair of Multimeter Test Leads

INSTRUCTIONS:

1. Each student is required to determine the defective component in a prefaulted voltage multipler circuit board. Your six-step troubleshooting sheet must indicate you used accurate test measurements and a logical procedure to find the faulty component.

2. Standard test equipment will be available to you in the form of an oscilloscope, a digital multimeter and a Simpson 260 multimeter. You will be expected to observe all safety precautions throughout the test. Improper use of test equipment is a safety violation will result in an automatic failure of the performance test. In that event, you will be counseled and given remedial training.

3. You will take a numbered position in the test room. After briefing by the Learning Center Instructor you will fill out the heading of the troubleshooting form. On a signal from the Learning Center Instructor you will then start the test. If at any time during the test you should require assistance, raise your hand. DO NOT LEAVE YOUR POSITION.

A Learning Center Instructor will assist you in your trouble. If the trouble is due to no fault of your own, you will not be penalized and a time extension will be given if necessary.

4. You must identify the faulty component or fault to pass this performance test.

5. If you do not understand these instructions, raise your hand and ask your learning center instructor. If you do understand these instructions, upon a signal from your learning center instructor you may now begin the performance test.

NOTE: You may remove the circuit board to make resistance checks.

SIX-STEP TROUBLESHOOTING PROCEDURES

FOR

TROUBLESHOOTING PERFORMANCE TEST

STEP ONE - SYMPTON RECOGNITION

1. The voltage multiplier is normally used to supply a high voltage to a Cathode Ray Tube (CRT) circuit. In this course a neon lamp has been inserted to simulate a CRT. Check the state of the neon lamp, then proceed to step two.

STEP TWO - SYMPTON ELABORATION

1. Does the equipment energize?
   a. Front panel meters
   b. Power on light
   c. Neon light
      (1) Normal
      (2) Dim
      (3) Unlighted
2. What do the meters indicate?
   a. Normal
   b. High
   c. Low
   d. Zero
3. Are the front panel controls properly adjusted?
4. Is the equipment plugged into an outlet?

STEP THREE - LIST THE PROBABLE FAULTY FUNCTION(S)

1. There are three functions in a voltage tripler. Check the faulty functions.
   a. Primary circuit
   b. Half-wave rectifier
   c. Voltage doubler
2. You can ligically determine the probable faulty function(s) by comparing the meter and light indications. For example, suppose the front panel meter indicates 40 VDC and the neon light is dim. These symptoms point to the voltage doubler section of the tripler circuit. The logic is as follows:

   a. A reading of 40 VDC on the meter indicates the half-wave rectifier circuit is functioning properly. (CR1-C3 etc.)

TROUBLESHOOTING PERFORMANCE TEST

b. The voltage doubler section furnishes 85 of the total 125 VDC output.The dim condition of the light indicates there is enough voltage to ionize the bulb (about 60 VDC) but not to full brightness.Since the half-wave section is good, the problem must be in the doubler.

STEP FOUR - LOCALIZE THE FAULTY FUNCTION

1. Verify the probable faulty function by using your test equipment.
2. List the test points where voltages/waveforms were obtained.
3. Reference voltages and waveforms are listed in voltage/waveform charts.
4. Which function listed in step three above is the faulty function?

STEP FIVE - LOCALIZE THE FAULTY CIRCUIT/COMPONENT

1. List the test points where actual voltages/waveforms were taken.
2. What circuit/component in the faulty function listed in step four is faulty?
3. If you have determined the faulty circuit but not the faulty component proceed to step six.

STEP SIX - FAILURE ANALYSIS

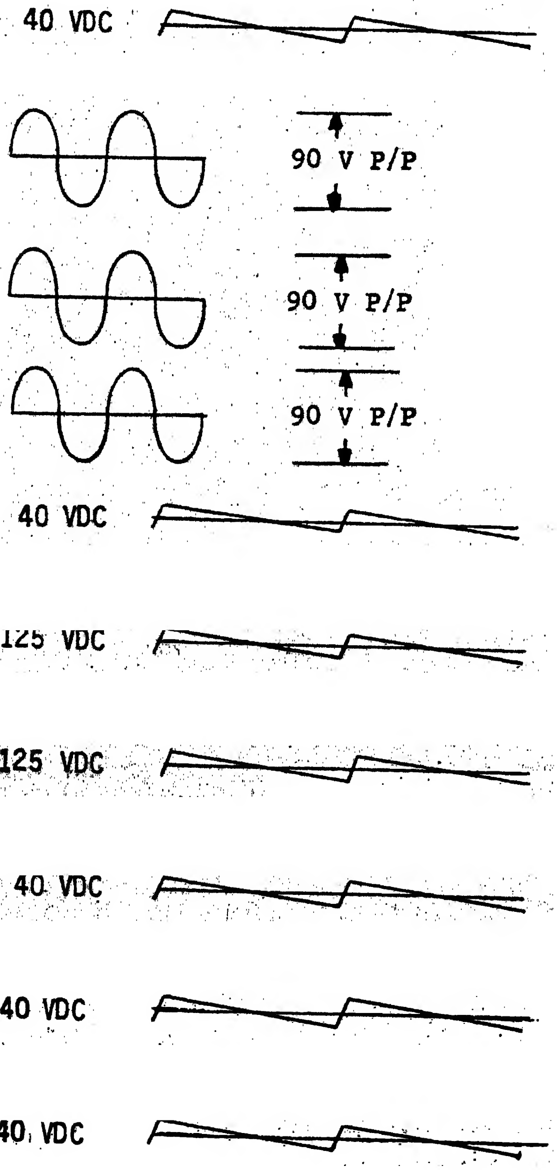
1. Secure the power and using the ohmmeter take resistance checks.
   a. Check front to back ratios on diodes.
   b. Take continuity checks on printed circuit board foil.
   c. Capacitors can be shorted or open.
   d. Resistors can be open.
2. Explain in your own words why the component listed in steps five or six above would cause the symptoms listed in steps one and two of the six step troubleshooting procedure? Write your answer in the space provided below.

TROUBLESHOOTING WAVEFORM/VOLTAGE CHART

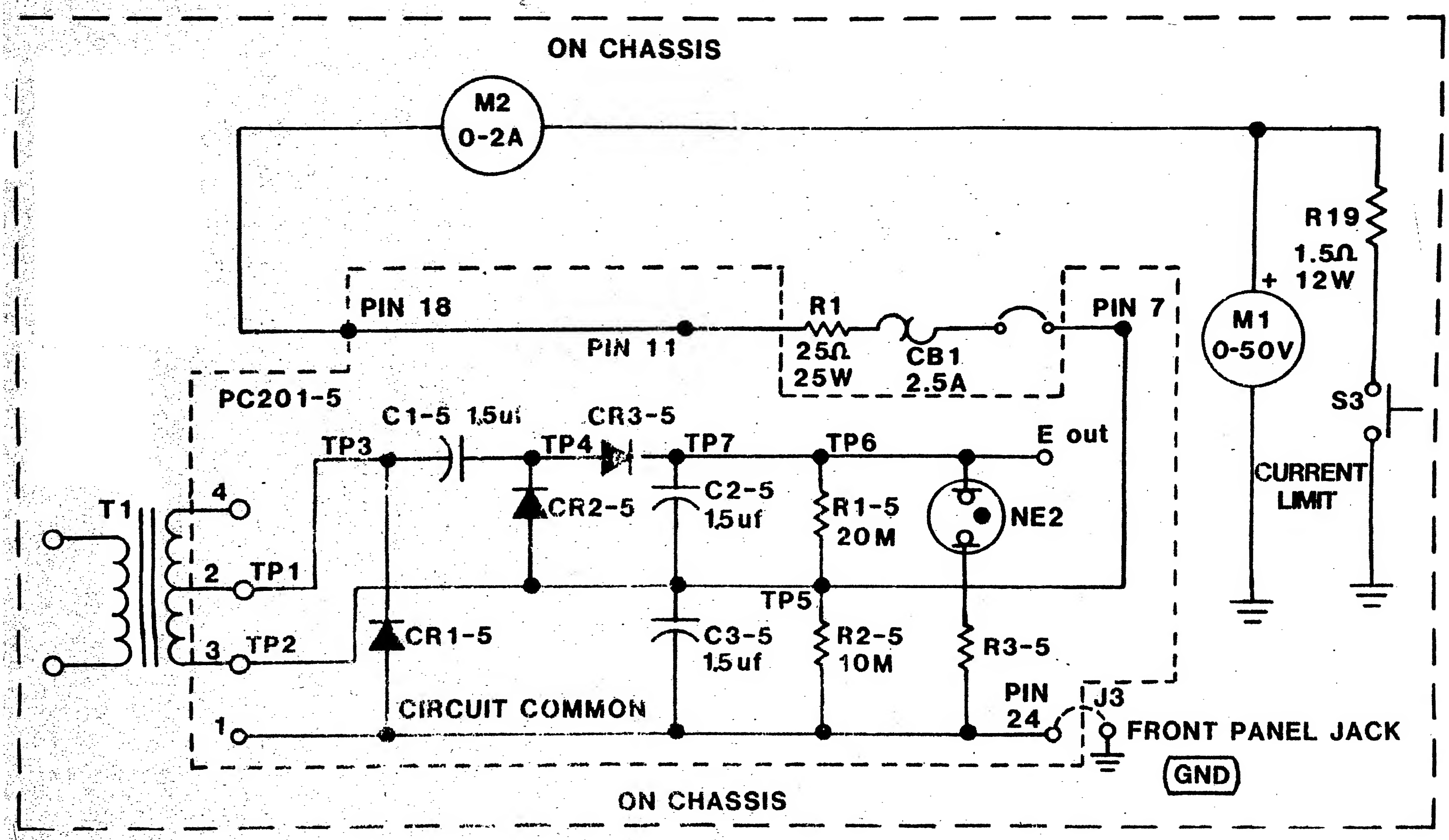
FOR

VOLTAGE TRIPLER PCB 201-5

THESE WAVEFORMS/VOLTAGES WERE MEASURED IN A PROPERLY OPERATING VOLTAGE TRIPLER. ALL MEASUREMENTS WERE TAKEN FROM THE INDICATED POINT TO COMMON. TOLERANCE IS +/- 5% WHEN TAKEN WITH A DVM AND +/- 20% WHEN USING A VOM (SIMPSON 260). THE LINE VOLTAGE FOR THESE REFERENCES IS 117 V RMS.



	OSCILLOSCOPE WAVEFORMS	DVM VOLTAGES
TP2	40 VDC	40 VDC
TP1	90 V P/P	40 VDC
TP3	90 V P/P	40 VDC
TP4	90 V P/P	86 VDC
TP5	40 VDC	40 VDC
TP6	125 VDC	125 VDC
TP7	125 VDC	125 VDC
PIN 7	40 VDC	40 VDC
PIN 11	40 VDC	40 VDC
PIN 18	40 VDC	40 VDC



VOLTAGE TRIPLER

ANSWER SHEET FOR
JOB PROGRAM
LESSON 1

10. a. 44.7 Vpk $\pm$ 5%
    b. 31.6 VAC $\pm$ 5%

11. a. 60HZ
    b. Half wave

12. 132VDC $\pm$5%

13. Three times

14. 87.0VDC $\pm$5%

15. Two thirds

16. 44.4VDC $\pm$5%

17. One third

18. a. 2:1

19. C1-5, CR2-5, CR3-5, C2-5 and R1-5

20. CR1-5, C3-5 and R2-5

21. To provide a long discharge time for C2-5 and C3-5

22. a. 50V
    b. 44VDC $\pm$5%
    c. The meter movement would be destroyed.

24. 44.4VDC $\pm$5%

THE ABOVE TOLERANCES ARE $\pm$5% WHEN TAKEN WITH A DVM AND $\pm$20% WHEN USING A VOM (SIMPSON 260).

ANSWERS FOR
PROGRESS CHECK
LESSON 1

QUESTION No.	CORRECT ANSWER	QUESTION No.	CORRECT ANSWER
1.	a.	5.	c.
2.	b.	6.	d.
3.	b.	7.	a.
4.	b.	8.	c.
		9.	b.